Sept. 25, 1934. M. HURST 1,974,851

GOVERNOR FOR INTERNAL COMBUSTION ENGINES

Filed May 29, 1930 2 Sheets-Sheet 1

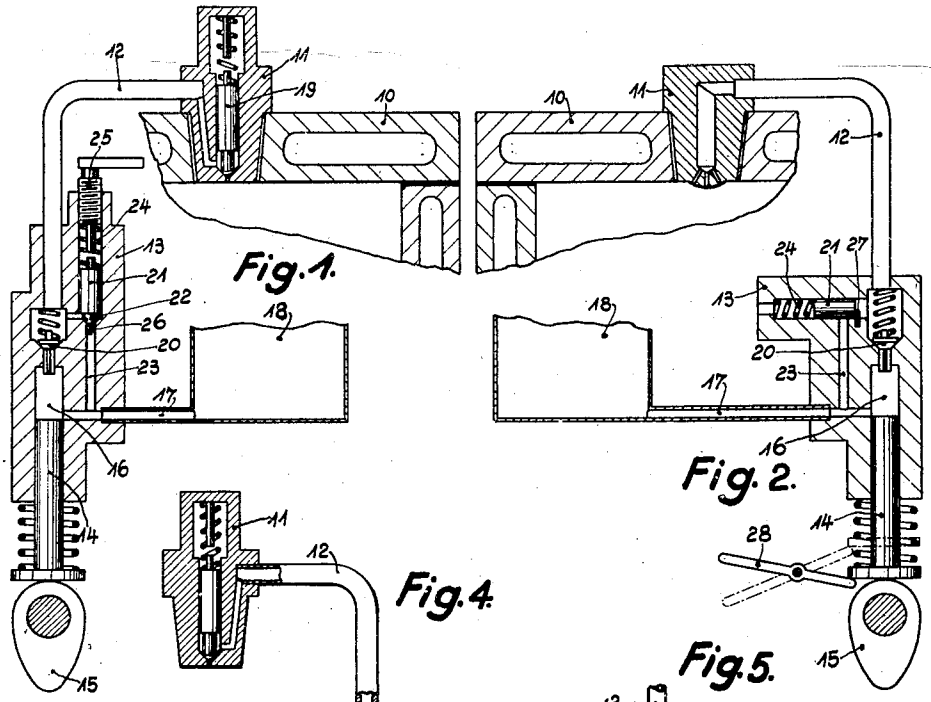


Fig. 1.

Fig. 2.

Fig. 4.

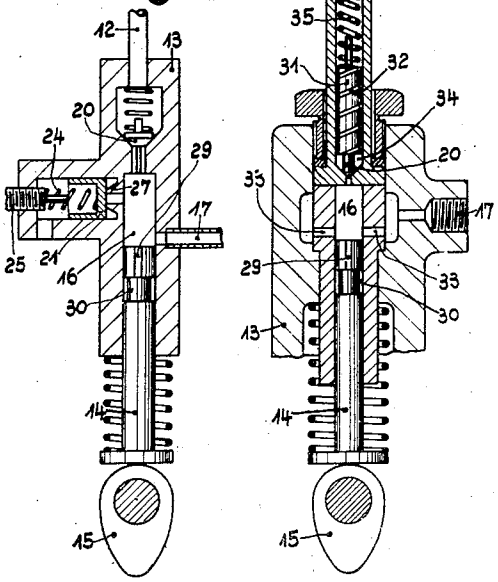


Fig. 3.

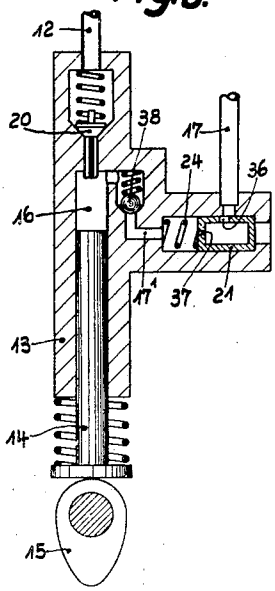


Fig. 5.

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Fig. 6.

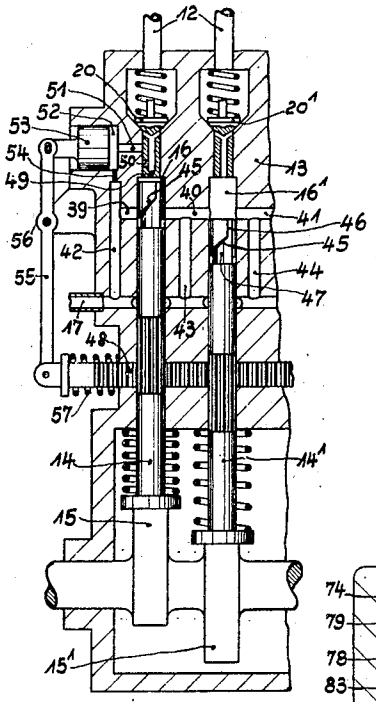


Fig. 8.

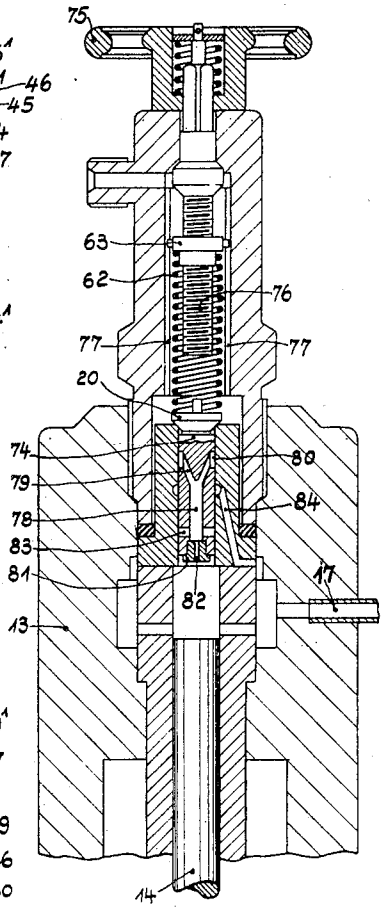
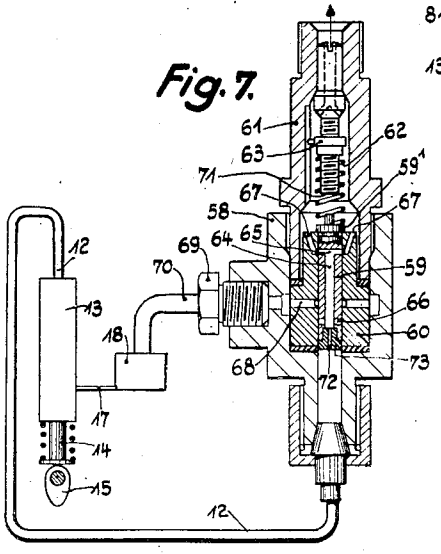


Fig. 7.



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UNITED STATES PATENT OFFICE

1,974,851

GOVERNOR FOR INTERNAL COMBUSTION ENGINES

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Application May 29, 1930, Serial No. 457,288
In Germany November 23, 1929

13 Claims. (Cl. 103—42)

The present invention relates to governors for internal combustion engines and is particularly applicable for the speed control of internal combustion engines fed by fuel oil on the solid injection or air injection systems.

In internal combustion engines, more particularly in the case of air injection and solid injection Diesel motors, it is usual to use a governor, usually of the centrifugal type, for controlling the quantity of fuel supplied for combustion so that any desired speed of revolution may be retained.

According to the present invention hydraulically operated means are provided in the path of the fuel for regulating the supply of fuel to the engine.

The invention is more particularly described with reference to the accompanying drawings which show, in part sectional elevation, eight forms of constructions by way of example.

In the first form of construction according to Figure 1 a fuel nozzle 11 is mounted in the cylinder cover 10 of an engine. A pipe 12 connects the nozzle with a fuel feed pump 13. The piston or plunger 14 of this pump is forced into the pump cylinder 16 by a cam 15 timed in accordance with the engine cycle and thus forces the fuel, fed to the cylinder 16 from a fuel container 18 through a suction pipe 17, over a non-return valve 20 and through the pipe 12 to the nozzle 11, the spring-loaded needle valve 19 of which opens the nozzle orifice at a given pressure so that the fuel is sprayed into the engine cylinder.

In addition to the pump piston there is mounted in the pump body 13 a second piston 21 which closes a channel 23 connecting the pressure pipe 12 of the pump with the suction pipe 17 by means of a needle-like stop 22 as long as the force exerted on the piston by a spring 24 is greater than the hydraulic pressure of the fuel operating upon it. The loading of the spring 24 can be varied by an adjusting screw 25.

This first form of the invention operates as follows:—

During its suction or down stroke the piston 14 first produces a vacuum in the pump cylinder 16 until the end of the suction duct 17 is uncovered, when fuel flows into the pump cylinder. As the piston moves from the outer or lower position shown, it begins, after the end of the suction duct 17 is closed, to discharge through the valve 20 into the pressure pipe 12. As soon as a predetermined pressure is attained there, the nozzle needle is raised and the fuel begins to spray through the nozzle orifice into the combustion space of the engine cylinder. Spraying of the fuel discharged by the piston 14 can be continued until a predetermined rate of fuel discharge is attained, and consequently until a predetermined engine speed is reached without the pressure in the pump chamber and in the pressure pipe being increased to that pressure at which the piston 21 is moved and the valve 22 consequently opened. As long as this state is continued, all the fuel discharged by the piston 14 is injected into the engine cylinder through the nozzle.

If the speed of the engine and consequently the discharge velocity of the piston 14 exceeds the predetermined value, then the pressure in the pump chamber and in the pressure pipe increases so that the piston 21 is displaced against the force of the spring 24 and the valve 22 opened, whereby fuel can escape from the pressure pipe through the now open connection from this pipe into the suction pipe.

The whole of the fuel discharged by the piston 14 is now no longer injected, the amount being reduced by the fuel returned through the valve 22, whilst the proportion of the discharge return increases with the engine speed. At a given engine speed therefore there is only so much fuel discharged as is necessary to retain this speed. The effective discharge is thus automatically adjusted in accordance with the tendency of the engine to increase its speed of rotation, and as shown the variation in the pressure difference between the two pressure surfaces of the piston 21, dependent upon the rate of fuel discharge, is used for this purpose.

In order that the valve 22 after opening is not immediately closed again by the reduction in pressure caused by such opening, a throttle is provided in the return flow channel 23 so that the effective piston surface is increased after movement. In the example shown this throttle consists of an annulus formed between the wall of the return flow channel 23 and a peg 26 mounted on the valve 22.

By altering the loading of the spring 24 by means of the screw 25 the speed of the engine can be altered as can be easily seen, since the hydraulic pressure required to displace the valve 22 is varied. It is therefore possible to suitably adjust the engine speed simply by altering the load on the member controlling the return flow channel. This simple means of adjustment is particularly valuable for vehicle engines.

In order to be able to stop the engine at any time it is only necessary to relax the spring 24 so far that the valve 22 is opened under a lower fluid pressure than the nozzle pressure whereby

the fuel discharged by the pump can flow back to the suction pipe through the valve 22.

The second form of construction shown in Figure 2 differs from the first mainly in that the movable regulating member, piston 21, itself controls the return flow channel 23 instead of the valve 22 provided in the first example. Instead of a closed fluid injection nozzle, an open nozzle provided with a plurality of holes is used in the second example. The path of the regulating piston 21 is limited by a stop 27. The mode of operation is exactly similar to that of the first example.

If it is desired to shut off the engine in the construction according to Figure 2, it is only necessary to hold the pump piston 14 in its inner or raised position by means of a lever 28 in known manner, so that the pump ceases to work and therefore to discharge.

In the third form of construction according to Figure 3 a movable regulating member 21 does not control a return flow passage as in the above described examples, but is here constructed as a piston for a storage chamber in which a portion of the fuel discharged by the pump is temporarily stored. One side of the piston 21 is subject to the hydraulic pressure prevailing in the pump chamber 16 at any instant whilst the other side is loaded by means of a compression spring 24.

The mode of operation is as follows:—

The more the engine speed and therewith the discharge velocity increase, the more increases also the pressure in the pump chamber during the delivery stroke of the pump because, as in the examples above described, the time allowed for the discharge of the fuel through the injection nozzle is reduced. The loading of the piston 21 which is variable by means of a screw 25 may be so adjusted that the piston 21 is retained in its initial position until any predetermined pressure is obtained in the pump chamber and therefore until any given speed of rotation of the engine is attained. If the engine speed rises above this limit then the piston 21, due to the increase in hydraulic pressure, recedes from its stop-ring 27 during the pressure stroke of the pump piston and receives or stores in the space thus made available a portion of the fuel discharged by the pump piston.

Towards the end of its pressure stroke the pump piston places the pump chamber in communication with the suction pipe through a channel 29 and an annular groove 30. The piston 21 can now force the fuel taken up or stored during the previous part of the pressure stroke back into the suction pipe through the channel 29 and grooves 30 so that the piston 21 is again in its position of rest shown in the drawings, for the beginning of the next pressure stroke. If the speed of the engine is increased due to a reduction in the load thereon so that the pressure in the pump chamber is increased then the quantity of fuel delivered to the engine will be correspondingly decreased to that required for maintaining the normal engine speed.

In order to reduce as far as possible any irregularity or hunting in the automatic adjustment described above, provision must be made for obtaining adequate displacement of the piston 21 when the given maximum hydraulic pressure is reached. For this purpose the stop of the piston 21 is so formed that the effective piston surface is enlarged as soon as it is displaced from its stop.

In the fourth form of construction according to Figure 4 the hydraulically operated movable shaft 31 influencing the regulation of the fuel injected, is firmly attached to a movable needle of the loaded valve 20 and extends behind the valve 20 into the pressure pipe leading to the engine. The shaft or piston 31 would shut off the fuel passage if a channel were not provided which in the case illustrated is formed as a helical screw groove 32 on the circumference of the shaft which allows the throttled passage of the fuel. The throttling of the fuel in the groove 32 causes a fall in pressure, varying with the engine speed, between the end surfaces of the shaft 31 which is displaced against the resistance of a spring 35 when the pressure drop is attained.

This form of construction operates as follows:—

As soon as the suction and return flow channels 33 have been closed during the compression stroke of the pump piston 14 the valve 20 is raised by fuel pressure and the fuel is driven into the chamber 34 in front of the shaft 31. When a given engine speed is reached the throttling groove 32 does not allow the fuel to pass to the injection nozzle as quickly as it is discharged into the chamber 34, so that the piston-like shaft 31 is raised against the pressure of the spring 35 in order to increase the volume of the chamber 34 to provide accommodation for the excess fuel. Towards the end of the pressure stroke, in the same manner as in the preceding example, the pump chamber 16 is connected to the suction side of the pump through the channel 29 and the annular groove 30, whereby the spring 35 and the fuel pressure present above the shaft 31 force the valve 20 together with the shaft 31 downwardly into the position shown in Figure 4. The shaft in returning thus forces fuel from the chamber 34 back into the pump chamber. The pressure pipe above the shaft 31 is thus relieved of a certain amount of fuel and sometimes even partially emptied.

Before the beginning of the subsequent injection the pump piston must first force sufficient fuel past the valve 20 into the pressure pipe to replace the fuel withdrawn at the end of the preceding injection. The quantity of fuel to be replaced increases with increase in the lift of the adjusting member 31 and consequently with increase in fuel discharge velocity. Thus, the amount of fuel delivered to the engine at each injection is only just sufficient to maintain the desired engine speed.

In the fifth form of construction according to Figure 5 a movable regulating member 21 is provided in the suction duct of the fuel pump. The regulating member 21 is formed as a piston valve controlling the effective cross-sectional area of the suction pipe 17, the front side of the piston valve being subjected to suction or negative pressure and the opposite side to atmospheric pressure. A weak spring 24 tends to maintain the piston valve 21 in the position shown where the effective suction cross-sectional area controlled by it is greatest. The fuel entering through pipe 17 passes through a boring 36 and a throttle orifice 37 to a continuation 17′ of the suction pipe leading to the suction valve 38 whence contrary to the other examples it flows during the whole suction stroke into the pump chamber 16, which is filled to a greater or lesser extent according to the suction velocity.

The construction described operates as follows:—

As long as the motor does not run too quickly, the control piston 21 is not displaced. If the speed of the engine increases beyond a given limit then the fall in pressure in the passage 17' causes longitudinal motion of the valve 21 during the suction stroke with the result that the throttle opening at 36 is reduced or even closed. This reduction of the throttle opening 36 causes reduction in the quantity of fuel entering the pump chamber during the suction stroke, and therefore a reduced quantity of fuel injected into the engine.

In the example just described with reference to Figure 5 the filling of the pump chamber is regulated in contra-distinction to the previous cases in which an adjustable portion of the fuel sucked up during the suction stroke is returned or by-passed to the fuel supply.

In the sixth form of construction shown in Figure 6 the quantity of fuel discharged by a pump having a plurality of cylinders can be automatically regulated by the hydraulic action of the fuel in one cylinder.

In the pump body 13 are provided several cylinders 16, 16' in which pistons 14, 14' of the same type are moved by the cams 15, 15' mounted on a common shaft and displaced corresponding to the number of engine cylinders. The separate pumps have a common suction pipe 17. Into the pump cylinders open channels 39, 40, 41 which are connected by tap borings 42, 43, 44 to the suction pipe 17, the fuel discharged by the pistons passing over non-return valves 20, 20' into pressure pipes 12 leading to the injection nozzles not shown.

On the ends of the pump pistons 14, 14' and projecting into the cylinders are steering surfaces which cover channels 39 and 40 for a portion of the piston stroke and which are bounded on one side by the front edge of the piston and on the other side by an oblique edge 45. A groove 46 in each of the pistons connects the pump chambers 16, 16' with a recess 47 behind the oblique edge. By rotating the pistons by means of a toothed adjusting rod 48, the length of the steering surfaces covering the channels 39 and 40 may be varied. By this, the effective discharge quantity of each separate pump is altered since as soon as the inclined edge 45 opens the channel 39, the fuel displaced by the upwardly moving piston is forced back from the pump chamber 16 through the groove 46 and the recess 47 into the channel 39. The regulation of the quantity discharged by displacing the adjusting rod is the same in all the separate pumps.

For moving the adjusting rod 48 the fuel discharge velocity, variable with the engine speed, is used. The spring loaded non-return valve 20 is provided with a piston-like guide shaft which is bored longitudinally for passage of the fuel. The boring is throttled at one end 49 adjacent the pump piston 16 and a radial branch 50 from the boring is adapted to register with a channel 51 in the pump body when the valve 20 has been raised sufficiently. The channel 51 leads to a chamber 52 in which a piston 53 is fitted and a throttle bore 54 leads from the chamber 52 to the channel 42 connected to the suction pipe.

An arm or projection on the end of the piston 53 is articulated to one end of a lever 55, which is pivotally mounted at 56. The other end of the lever 55 is connected to the end of the adjusting rod 48, which is urged into the position shown by a spring 57.

The pump described operates as follows:—

As long as the engine does not run too quickly, the control mechanism is not operated. If the speed of rotation increases then the difference in the pressures acting on the spring-loaded valve 20 is also increased because the throttle orifice 49 will not allow the fuel discharged by the pump piston 14 to pass, in the reduced time available without an increase in pressure in the chamber 16. Thus the lift of the valve 20 is increased with increasing engine speed until at a given speed the cross-bore 50 in the shaft of the valve 20 uncovers the channel 51 so that a portion of the fuel discharged flows into the fuel-filled chamber 52 whereby the piston 53 is moved outwardly and its movement transferred through a lever 55 to the adjusting rod 48. This rotates all the pump pistons so that their effective discharge quantity diminishes whereby the engine speed is reduced. If the engine speed falls so far that no more fuel passes into the chamber 52, then the spring 57 begins to return the adjusting rod together with the pump piston and also the piston 53 to their former positions, so that the effective discharge quantity again increases. The fuel forced out during the return of the piston 53 flows off through the throttle boring 54 to the suction side of the pump.

In the seventh form of construction according to Figure 7 all the parts of the regulating arrangement are mounted in an intermediate housing, which is inserted anywhere in the pressure pipe leading to the injection nozzle.

Inserted in a boring of this housing is a guiding member 60 receiving a piston-like valve control member 59, and a closing nipple 61. A pressure spring 62, which on one side abuts against a collar 59' engaging with the valve and on the other side against an adjusting spring plate 63, tends to retain the valve in the position shown.

Branching from a longitudinal bore 64 in the control member 59 are transverse borings 65 and 66. The boring 65 is connected in the position of rest of the valve through a boring 67 in the guiding member 60 to the continuation of the pressure pipe leading to the injection nozzle whilst the borings 66 are shut off in the position of rest. After a given upward movement of the valve however the borings 66 connect the longitudinal boring 64 with a transverse boring 68 in the guiding member 60 which communicates through an outlet 69, and a pipe 70 with the fuel container 18. A stop 71 limits the stroke of the regulating valve. The longitudinal boring 64 is throttled at its inlet end by a plug 73 having a throttle orifice 72 formed therein.

The operation of the control mechanism is as follows:—

Up to a certain engine speed the throttle orifice 72 allows all the fuel discharged by the pump to pass through without sufficient increase of pressure arising in the pipe 12 to raise the piston 59 against the pressure of the spring 62. If however the engine speed increases further, the throttle orifice 72 only allows the fuel discharged to pass through under an increased pressure, which is able to overcome the counter forces acting on the controlling piston 59, and to raise it. After a small movement of the piston

the transverse boring 65 ceases to register with the channels 67, so that the flow through to the throttle orifice is interrupted. The pump, however, continues to discharge and the controlling piston 59 is therefore quickly forced upwardly until the borings 66 register with the channel 68 and thus open a return flow path for the fuel further discharged. The more the speed of rotation is increased the more quickly will this return path be opened.

The control mechanism may be adjusted to allow sufficient fuel to pass without lifting of the piston 59 to maintain a given engine speed.

In the eighth form of construction according to Figure 8 the shaft 74 of the spring-loaded valve 20 is guided in the manner of a piston, and is so formed that on return of the valve into its closed position it relieves the pressure pipe. Moreover, the shaft 74 controls the return flow of a portion of the fuel discharged by the pump 14 dependent upon the discharge velocity. The loading of the valve spring 62 can be adjusted by the hand wheel 75. By rotating the hand wheel, the screw spindle 76, serving at the same time as a stop for the valve stroke displaces the spring-abutment plate 63, restrained in lateral grooves 77 against rotation therewith.

Formed in the shaft of the valve 20 is a longitudinal boring 78. Inclined channels 79 lead from the inner end of the longitudinal boring 78 to an annular groove 80, formed in the shaft. In the inlet end of the shaft is a plug 81 having a throttle orifice 82 formed therein. After a certain lift of the valve a transverse boring 83 in the guiding shaft thereof connects the longitudinal boring with a return flow channel 84.

The method of operation of this eighth form of construction will be understood from what has been stated in reference to the two preceding examples. It has also been described in detail with reference to the third example how the change of tension of the spring acting on the controlling member, which in the present case is the forcing valve spring 62, changes the maximum engine speed.

Instead of adjusting the engine speed by varying the loading of the spring, it may also be influenced by varying the stroke or movement of the valve necessary for effecting return of discharged fuel or by adjusting or altering the throttle orifice which causes a pressure drop thus effecting movement of the control piston. This pressure drop could also be produced by a Venturi tube instead of a throttle. One means of obtaining a low degree of irregularity in the present control mechanism is to so form the driving cams that over the portion of the stroke in which the regulation is to be effected, the discharge velocity remains almost constant.

In all the forms of construction described the movable adjusting member is formed as a piston valve. Instead of this valve a diaphragm could in many cases be used. Within the scope of the invention many modifications can be made of the examples described which only relate to internal combustion engines having a fuel pump for each motor cylinder. The regulating means described can also be used for other types of motors for example for blast air injection motors. The idea of the invention is applicable to all fuel discharging members, in which the velocity of the fluid increases with the speed of rotation.

I claim:

1. A fuel supply and regulating system for internal combustion engines comprising in combination at least one pump chamber, a piston within said chamber rotatable about its longitudinal axis for varying the effective discharge thereof, actuating means for rotating said piston, a spring loaded piston adapted to be connected with the discharge side of said pump chamber governing said actuating means and a spring loaded piston valve having a fuel passage therethrough and a throttle orifice at the inlet end of the passage for controlling the connection of the spring loaded piston with the pump chamber.

2. A fuel supply and regulating system for internal combustion engines comprising in combination a fuel pump, a discharge duct from said pump to an engine, an inlet duct to said pump from a fuel supply, a by-pass from said discharge duct to the fuel supply and a spring loaded piston valve sliding in said discharge duct, having a fuel passage therethrough leading to the engine and a throttle orifice at the inlet end of the passage for controlling said by-pass.

3. A fuel supply and regulating system for an internal combustion engine comprising in combination a fuel pump operated by said engine, a fuel supply line connecting a source of fuel to said engine through said pump, a throttling device located in said supply line on the discharge side of said pump, and means comprising a by-pass opening from said supply line on the discharge side of said pump between said throttling device and the engine and leading to said supply line on the intake side of said pump and a valve member in said supply line on the discharge side of said pump movable over said by-pass opening in response to the pressure drop produced by said throttling device to control the amount of fuel delivered to said engine, said valve member having one face exposed with said throttling device to the full discharge pressure of said pump and another face exposed to the pressure in said delivery duct on the engine side of said throttling device.

4. A fuel supply and regulating system for an internal combustion engine comprising in combination, a fuel pump positively driven by said engine so that the velocity of discharge of fuel from said pump varies directly as the engine speed, a fuel delivery duct from said pump to said engine and means for controlling the quantity of fuel delivered to the engine comprising a by-pass opening from said delivery duct and leading to the intake side of said pump and a piston valve located in said fuel delivery duct and operating over said by-pass opening to control the discharge of fuel through said by-pass, said piston valve having a throttling aperture formed therein leading to the engine and through which the fuel flows, whereby said valve is operated in accordance with the pressure difference developed in said fuel delivery duct on the two sides of the piston.

5. A fuel supply and regulating system for an internal combustion engine comprising, in combination, a fuel pump positively driven by said engine whereby the velocity of discharge of said pump varies directly with the engine speed, a fuel delivery duct leading from the discharge side of said pump to said engine, a by-pass opening from said fuel delivery duct and leading to the intake side of said pump, a pressure-operated valve movable in said delivery duct over said by-pass opening and operated in the opening direction by pressure thereagainst of the fuel discharged from said pump, and means for controlling the opening movement of said valve directly in accordance

with changes in velocity of discharge of fuel from said pump comprising a fuel throttling device located in said delivery duct between said pump and said by-pass opening and operating to build up a fuel pressure against said valve in direct proportion to increase in velocity of the total fuel discharged from said pump, said valve having one face exposed with said throttling device to the full discharge pressure of said pump and another face exposed to the pressure in said delivery duct on the engine side of said throttling device.

6. A fuel supply and regulating system for an internal combustion engine comprising, in combination, a fuel pump positively driven by said engine whereby the velocity of discharge of said pump varies directly with the engine speed, a fuel delivery duct leading from the discharge side of said pump to said engine, and means for controlling the amount of fuel delivered to said engine comprising a by-pass opening from said fuel delivery duct and leading to the intake side of said pump, a loaded element in said duct movable by the pressure thereagainst of fuel discharged from said pump and having a valve portion operating over said by-pass opening to control said by-pass, a passage for the flow of fuel through said element from said pump to said engine and a throttling restriction at the entrance to said passage operative to so increase the fuel pressure on said element as the engine speed and consequent discharge of fuel from said pump increases as to move said element against its load to an extent opening said by-pass when a predetermined engine speed has been reached.

7. A fuel supply and regulating system for an internal combustion engine comprising, in combination, a fuel pump positively driven by said engine whereby the velocity of discharge of said pump varies directly with the engine speed, a discharge duct from said pump to said engine, a by-pass for fuel from the discharge side to the intake side of said pump, and means for closing said by-pass up to a predetermined engine speed and thereafter opening the same comprising a pressure-operated valve member located and movable in said discharge duct and having one face exposed to the pressure in said discharge duct on the engine side of said member and a loading tending to move said member in a direction effecting closure of said by-pass, said valve member having an opposite face exposed to the pressure created by said pump on its discharge stroke, a duct connecting said opposite faces of said valve member upon the discharge stroke of said pump and a throttling restriction in said duct operative to produce such a pressure difference on said opposite faces of said valve member at a predetermined speed of said engine and corresponding velocity of discharge of fuel from said pump as to move said valve member against its load sufficiently to open said by-pass.

8. A fuel supply and regulating system as defined in claim 7 and in which said duct connecting said opposite faces of said valve member is formed in said valve member itself.

9. A fuel supply and regulating system for an internal combustion engine comprising, in combination, a fuel pump positively driven by said engine whereby the velocity of discharge of said pump varies directly with the engine speed, a discharge duct from said pump to said engine, a by-pass for fuel opening from said discharge duct and leading to the intake side of said pump, a pressure-operated valve member located and movable in said discharge duct over said by-pass opening to control said by-pass, said valve member having an end surface exposed to the pressure in said discharge duct on the engine side of said by-pass opening and a loading tending to move said member in a direction effecting closure of said by-pass, said valve member having an opposite end surface on the pump side of said by-pass opening exposed to the pressure created by the pump on its discharge stroke, a duct connecting said opposite end surfaces of said valve member upon the discharge stroke of said pump and a throttling restriction in said duct on the pump side of said by-pass opening operating in response to changes in velocity of the total fuel discharge from said pump to effect such a pressure difference on said opposite end surfaces of said valve member as to maintain said valve member in position closing said by-pass until a predetermined engine speed and corresponding velocity of fuel discharge from said pump has been reached and then to move said valve member sufficiently to open said by-pass.

10. A fuel supply and regulating system for an internal combustion engine comprising, in combination, a fuel pump positively driven by said engine whereby the velocity of discharge of said pump varies directly with the engine speed, a discharge duct from said pump to said engine, a by-pass for fuel from the discharge side to the intake side of said pump, a pressure-operated discharge valve for said pump having a linear movement in said duct, said valve having a passage through its body formed with a throttling restriction at the inlet end on the pump side of the valve arranged for the flow therethrough in the open position of said valve of fuel from said pump to said engine, said passage and throttling restriction in said valve being of such dimensions for the flow of fuel therethrough and said valve having such a loading as to vary the length of stroke of the valve in the opening direction directly with the velocity of discharge of fuel from said pump consequent upon the speed of said engine, a valve for controlling said by-pass and a mechanical connection between said valves whereby said discharge valve maintains said by-pass valve closed until said discharge valve has advanced a predetermined distance in its opening direction less than the full length of its opening stroke and then effects the opening of said by-pass valve.

11. A fuel supply and regulating system for an internal combustion engine comprising, in combination, a fuel pump positively driven by said engine whereby the velocity of discharge of said pump varies directly with the engine speed, a discharge duct from said pump to said engine, a by-pass for fuel opening from said discharge duct and leading to the intake side of said pump, a non-return discharge valve in said discharge duct on the engine side of said by-pass opening having a skirt portion extending therefrom toward the pump and movable over said by-pass opening to maintain said by-pass closed until said discharge valve has moved a predetermined distance in opening direction less than the full length of its opening stroke and then to open said by-pass, said skirt portion being formed to provide an axial passage therethrough for the flow of fuel past said discharge valve to the engine in the open position of said fuel and a throttling restriction at the inlet end of said passage on the pump side.

12. A fuel supply and regulating system for an internal combustion engine comprising, in com-

bination, a fuel pump positively driven by said engine whereby the velocity of discharge of said pump varies directly with the engine speed, a discharge duct from said pump to said engine, a by-pass for fuel opening from said discharge duct and leading to the intake side of said pump, a pressure-operated piston valve located and movable in said discharge duct over said by-pass opening to control said by-pass, said piston valve having one end face in said discharge duct on the engine side of said by-pass opening and a loading tending to move said valve in a direction closing said by-pass and an opposite end face on the pump side of said by-pass opening exposed to the pressure created by said pump on its discharge stroke, said valve having a duct connecting said opposite end faces upon the discharge stroke of said pump and a throttling restriction in said duct on the pump side of said by-pass opening adapted to produce such a pressure difference on said opposite faces of said valve at a predetermined speed of said engine and corresponding velocity of discharge of fuel from said pump as to move said valve against its load sufficiently to open said by-pass.

13. A fuel supply and regulating system for an internal combustion engine comprising, in combination, a fuel pump positively driven by said engine whereby the velocity of discharge of said pump varies directly with the engine speed, a discharge duct from said pump leading to said engine, an annular valve seat in said duct, a by-pass for fuel opening from said discharge duct on the pump side of said valve seat and leading to the intake side of said pump, a pressure-operated piston body slidably mounted in said discharge duct and having a head portion forming a non-return discharge valve movable from and into engagement with said valve seat on the engine side thereof to control the delivery of fuel from said pump to said engine, said piston body having a rear portion on the pump side of said by-pass opening always exposed to the full delivery pressure of said pump and an axial passage therethrough with a throttling restriction at its inlet end and an outlet rearwardly adjacent said non-return valve in position to be closed when said valve engages said valve seat and to be opened for the flow of fuel therethrough and past said valve to the engine when said valve moves from said seat and an intermediate apertured portion formed to maintain said by-pass closed until said discharge valve advances a predetermined distance in its opening direction and then to open said by-pass.

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